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DESCRIPTION OF A PRELIMINARY GRAIN MANAGEMENT SYSTEM MODEL

by

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Introduction

The purpose of this working paper is to describe the broad outlines of a grain management system component for the Korean agricultural sector simulation model and tentative model structural details. The model details described should be viewed as "first iteration" subject to modification and addition as further information is obtained from computer runs and interaction with Korean policy makers and information sources.

In what follows we will present an overall description of the grain management model and its incorporation into the KASS agricultural sector model. We will then present tentative structural details of the sub-components of the model as they have been developed to date.

Broad Description of the Food Grain Management System Model

Figure (1) provides a description of the broad outlines of the model. The basic objectives of this model are to permit

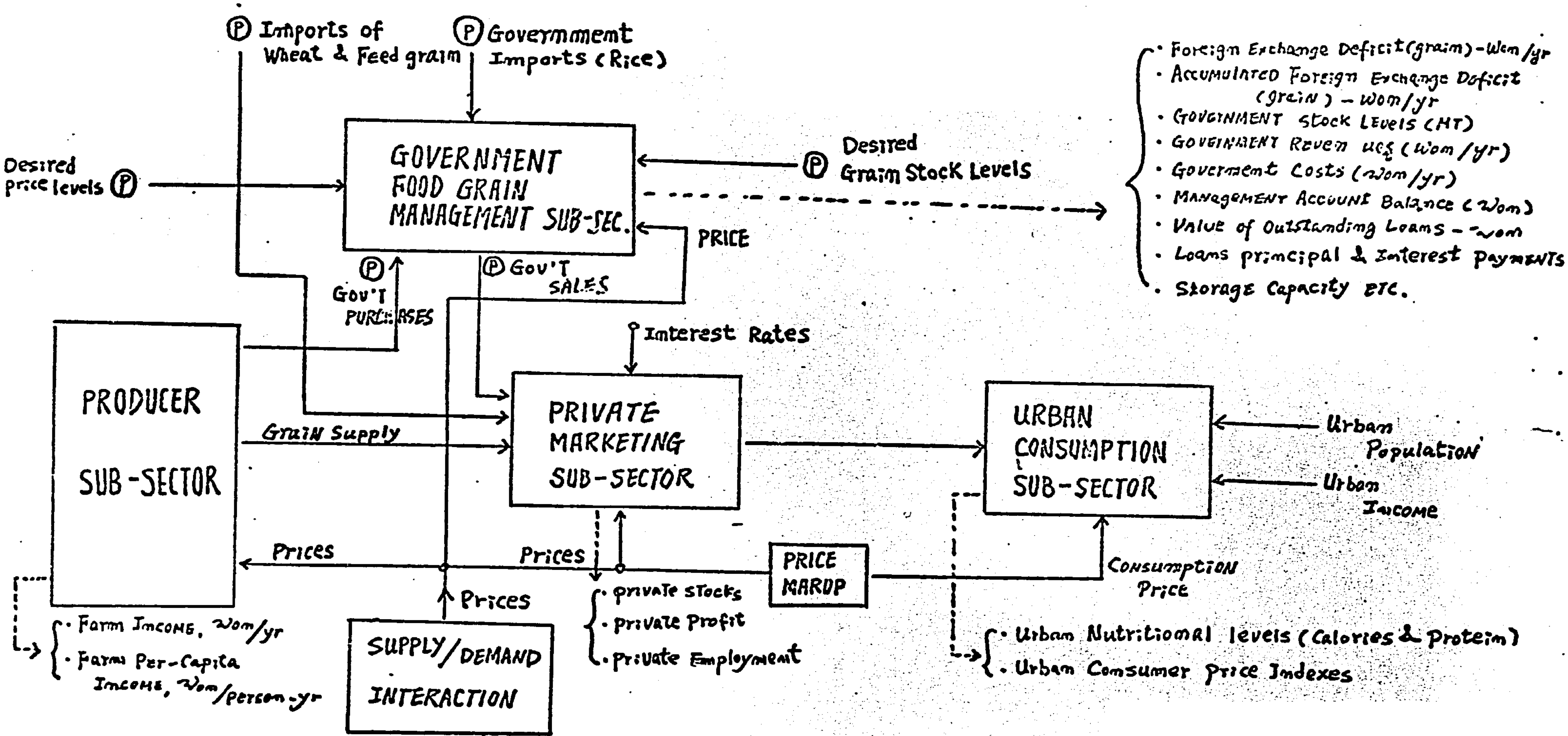

Figure 1. PRELIMINARY OUTLINES OF A FOOD GRAIN MANAGEMENT SYSTEM SIMULATION MODEL

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evaluation of alternative government food grain management policies upon the public and private sectors of the Korean economy. At this point in time the key government policy instruments included in the model are:

a. Government imports of rice.

b. Import quotas established for wheat and feed grains.

c. Amount and timing of government purchases and sales of rice and barley in domestic markets.

d. Desired levels of government reserve stocks of rice and barley.

e. Import tarrifs (if any) on wheat and feed grains.

f. Quantities of imports paid in cash and bought on a long term loan basis.

As shown in Figure (1) the model as conceptualized can compute a number of variables which permit evaluation of the impacts of alternative policies upon the public and private sectors. These include:

g. Domestic price levels of major grains - rice, barley, wheat, and feed

h. Seasonal stability of grain prices.

i. Aggregate farm income

j. Farm income per-capita

k. Urban consumer price indices

l. Urban nutrition levels per-capita (calories and protein).

m. Foreign exchange deficits from grains - \$/yr.

n. Accumulated foreign exchange deficits from grains (over some time horizon) -- \$.

o. Value of outstanding grain loans over time (\$ or won).

p. Payments to loan principle and interest over time (\$/yr or won/yr).

q. Costs of operating the grain management system - won/yr.

r. Net revenue received by the grain management system -- won/yr.

s. Net cash balance over time of the grain management account - won.

As shown in the figure there are four major sub-models which interact to determine the behavior of the overall grain management system model. These are:

1. The production component of the KASS agricultural sector simulation model. This model computes, over time, the seasonal domestic supply of grains to urban markets. It does so as a function of the seasonal nature of grain production, farm consumption and the seasonal pattern of farm sales (in cash and in kind) into urban markets. Some additional work on this component is required to obtain realistic simulation of seasonal grain supplies.

2. The urban demand conponent of the KASS agricultural simulation model. This component computes yearly average demands for grains and other food items as a function of urban income, population, and price levels. Additional work is required simulate the seasonal behavior of consumer grain demand as influenced by storage in response to price fluctuations and seasonal fluctuation in consumption.

3. A private marketing sub-sector model to be constructed. This model will be constructed to approximate the behavior of the private grain marketing sub-sector in buying, selling and storing grain. This sub-sector model will include factors such as interest rates, seasonal price fluctuations, expected price fluctuations, profit from storage, etc. Some preliminary details of this model are included in a later section of this report.

4. Government grain management sub-sector model. This sub-model permits introduction of the policy alternatives (a-f) described above. It also computes a number of variables (m-s) above which permit evaluation of the effects of alternative policies upon the public sector. A preliminary version of this sub-sector model has been developed and details of its construction are presented in the following section of this paper.

Detailed Description of The Preliminary Grain Management System Model

In this section we will describe details of the structure of the government and private marketing sub-sectors of Figure (1). We will also outline some of the changes necessary in the production (PRODN) and urban demand (DEMAND) components of the KASS simulation model necessary for compatibility with the other sub models of the grain management system. The model details that follow should be regarded as tentative -- subject to revision as further information becomes available.

Government Sub-Sector Model

Basic to the operation of the grain management system are government stocks which permit the government to buy and sell

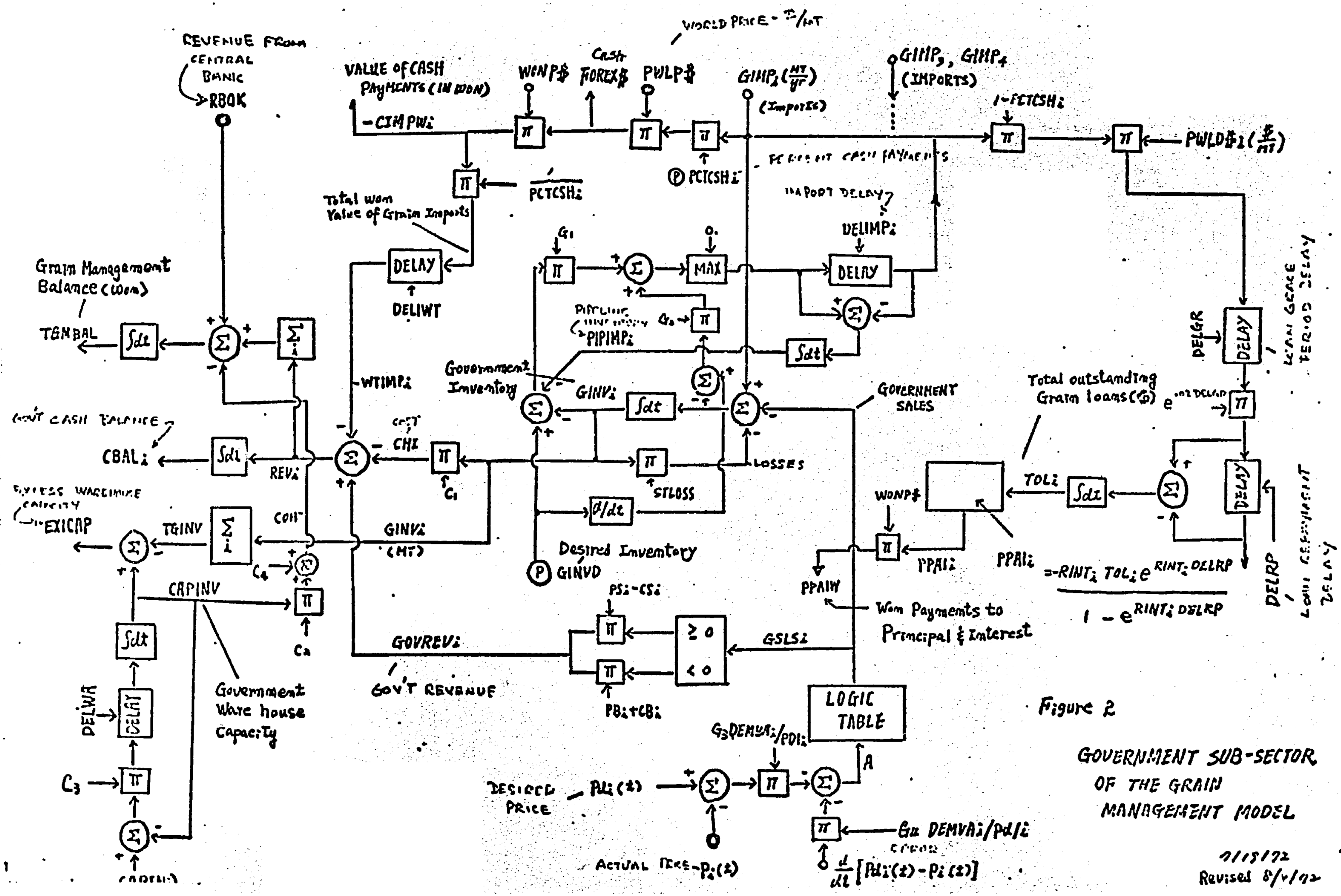

Figure 2

GOVERNMENT SUB-SECTOR OF THE GRAIN MANAGEMENT MODEL

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in domestic markets and thereby regulate price stability in the short run as well as long run price changes. Equation (1) computes government stocks over time for the commodities regulated by government actions.

1) $GINV_i\ (t + DT) = GINV_i(t) + DT^*\ [GIMP_i\ (t) - GSLS_i(t) - GSLOSS_i(t)]$

where:

$GINV_i$ = Government stocks of commodity i (MT)

$GIMP_i$ = Government imports of commodity i (MT/yr)

$GSLS_i$ = Government sales (MT/yr)

$GSLOSS_i$ = Government storage losses (MT/yr)

DT = The basic time increment used in the simulation - nominally .025 yr.

In this and following equations the index i runs from 1 to 2 and designates rice and barley respectively. If additional commodities are brought under government control the same basic model could be used by running the index i over the commodities added.

Government storage losses in Equation (1) are computed as

2) $GSLOSS_i(t) = STLOSS * GINV_i\ (t)$

where STLOSS is the proportion of storage lost or damaged per year expressed in MT/MT-yr.

Computation of government sales (GSLS) in Equation (1) is somewhat more complicated. It is assumed that government buys and sells in the markets to adjust prices toward what it considers to be desired or target prices. Government can take these purchase or sales actions only if:

a) It has the necessary financial resources.

b) It has the storage space necessary to hold the stocks that will result from the actions taken.

c) It has stocks available when it desires to sell.

We will begin by computing the purchases or sales government would like to make to regulate prices in the absence of constraints. This variable, called "A" is computed as

$$3) \quad A_i(t) = G3_i \, DEMUA_i (PD_i(t) - P_i(t))/PD_i(t) + G4_i \, DEMUA * DPEDT_i(t)/PD_i(t)$$

where:

A_i = Government sales (MT/yr) to control market price (assuming that no constraints limit government actions). If this variable is negative the government is buying in theparticular commodity market.

PD_i = Desired or target market price (won/MT). This variable is established by policy and can introduce varying degrees of seasonal fluctuation as the target.1/

$P_i(t)$ =Actual market price - w/MT.

$DPEDT_i$ = Rate of change of the difference between $PD_i(t)$ and $P_i(t)$.2/

2/ The variable $DPEDT_i(t)$ is computed as $((PD_i(t))-PD_i(t-DT)))/DT$

1/ Specifically $PD_i(t) = PD1_i(1+PD2_i(TABLIE(....))$. The TABLIE function computes a seasonal price index that represents the average

Footnote cont.

seasonal price fluctuation in the <u>absense of government market operations.</u> The policy parameter $PD2_i$ represents the proportion of this "normal" variation government would allow to remain. The policy parameter $PD1_i$ represents the <u>average</u> price level government seeks to maintain.

$DEMUA_i$ = Average annual urban consumption of commodity i - MT/yr.

$G3_i$, $G4_i$ = Parameters determined by policy

The decision rule of Equation (3) has two components. The first provides for government market actions to correct for any discrepancy between desired and actual market prices (Pd and P). The second provides a correction if the actual price _is trending away from the desired price_. It therefore introduces a forecasting element into government actions. Note that this is only one of a number of government decision rules that might be investigated in the model.

As used in Eqn. (3) the parameter G3 represents the percent government purchases or sales of total marketed quantity (DEMUA) per percent difference between actual and desired price. The parameter G4 represents the percent change in government purchases or sales per percent change in the difference between desired and actual price per unit time. Both these parameters are determined by policy and influence the effectiveness of government programs to stabilize prices. One purpose of the model is to determine desirable values for these policy parameters.

As discussed above, government purchases and sales (the variable $GSLS_i$) are equal to A_i in Eqn. (3) if there are no physical or monetary constraints. The logic of Table I determines GSLS as influenced by these constraints. The table includes four logical conditions which may be either "true" or "false":

1) $GINV_i > 0$ - Government stocks non-zero for the ith commodity available.

2) $\sum_i GINV_i < GICAP$ - Government stocks less than total warehouse capacity,

3) $GBAL_i > 0$ - Government cash balance for new purchases greater than zero.

4) $A_i \geq 0$ - Government intends to sell commodity i.

A "one" in the column for a given logical conditions indicates that the condition is "true" and a zero that it is "false". In all there are sixteen possible combinations of the four logical conditions and these are enumerated in Table I. Four of these are not feasible and the remaining 12 determine the value assigned to $GSLS_i$ in the model as shown in the table.

Given $GSLS_i$ thus determined, government revenues ($GOVREV_i$) from purchases and sales of commodity i are given by:

4) $$GOVREV_i(t) = GSLS_i(t)*(PS_i(t)-CS_i) \text{ if } GSLS_i \geq 0$$
$$= GSLS_i(t)*(PB_i(t)+CB_i) \text{ if } GSLS_i < 0$$

where:

PS_i = Government selling price for the ith commodity. won/MT

CS_i = Government costs related to selling (transport, etc.) - won/MT

Value Assigned To: $GSLS_i$	Logical Conditions (1) $(GINV_i > 0)$ (1 = have slack)	(2) $(\sum_i GINV_i < GICAP_i)$ (1 = have warehouse space)	(3) $(GBAL_i \geq 0)$ (1 = have revenue to buy)	(4) $(A_i \geq 0)$ (1= desire to sell)
1) A_i	1	1	1	1
2) A_i	1	1	1	0
3) A_i	1	0	1	1
4) 0	1	0	1	0
5) A_i	1	1	0	1
6) 0	1	1	0	0
7) 0	0	1	1	1
8) A_i	0	1	1	0
9) Not Logically Feasible	0	0	1	1
10) Not Logically Feasible	0	0	1	0
11) 0	0	1	0	1
12) 0	0	1	0	0
13) A_i	1	0	0	1
14) 0	1	0	0	0
15) Not Logically Feasible	0	0	0	1
16) Not Logically Feasible	0	0	0	0

Table I

Logic Table for GSLS

PB_i = Government buying price for commodity i-won/MT

CB_i = Government costs related to buying (above price of r grain) - won/MT

Imports in the model are computed from the following equations. The rate at which orders are placed for import of commodity i is:

4) $RIMPI_i(t) = G1_i * (GINVD_i(t) - GINV_i(t) - PIPIMP_i(t))$
$G2_i * DINVE(t)$

where:

$RIMPI_i$ = Import orders - MT/yr.

$GINV_i$ = Current level of inventory - MT

$GINVD_i$ = Desired government stock level of commodity i - MT (this may be fixed or dependent upon other system variables).

$DINVE_i$ = The time rate of change of $(GINVD_i(t) - GINV_i(t) - PIPIMP_i(t))$

as approximated by

$DINVE_i(t) = ((GINVD_i(t) - GINV_i(t) - PIPIMP_i(t)) - (GINVD_i(t-DT) - GINV_i(t-DT) - PIPIMP_i(t-DT))/DT$

$G1_i$ = A parameter set by policy determines the rate at which import orders are placed per unit of discrepancy between desired and actual inventory.

$G2_i$ = A parameter set by policy - determines the rate at which import orders are placed per unit rate of change in desired minus actual inventory.

The basic assumption is made in the model that Korea will continue to have domestic grain deficits. Imports are therefore constrained to be non-negative (no exports allowed) by Equation (5):

5) $RIMPI_i(t) = MAX\,[RIMPI_i(t), 0]$

The model uses a distributed delay to simulate the lags involved in processing import orders and transporting grain to Korean ports and then to government warehouses. A DELDT subroutine is used to implement this delay as shown by (6):

6) CALL DELDT ($RIMPI_i$, $GIMP_i$, $RINTIP_i$, $DELIMP_i$, IDTIMP, DT, KIMP)

where:

$RIMPI_i$ = Rate at which orders are placed for imports-MT/yr.

$GIMP_i$ = Rate at which imports arrive at government warehouses - MT/yr.

$RINTIP_i$ = An array of KIMP intermediate rates.

DELIMP = Importation delay - years (the average elapsed time between ordering of imports and arrival of grain at government warehouses.)

KIMP = A parameter that determines the shape of the probability distribution function for the import delay (applies to individual units of grain as they arrive at government storage facilities).

DT = Time increment used in the simulation.

The amount of grain which has been ordered but not yet received is the so-called pipeline inventory, PIPINV, computed as:

$$7)\quad PIPINV_i(t) = DELIMP_i * IDTIMP_i * \sum_{j=1}^{KIMP} RINTIP_{ij}(t) / KIMP$$

where all variables are defined as in Equation (6).

We now turn our attention to the model equations which simulate the debt obligations incurred from importing on a credit basis and the loan repayment obligations which become due over time.

The model policy parameter PCTCSH determines the proportion of imports that are paid for on a cash basis. The rate at which indebtedness is acquired is therefore:

$$8)\quad RGRACI_i(t) = GIMP_i(t)*(1-PCTCSH_i) * PWLD_i(t)$$

where:

RGRACI = The rate at which new loans are acquired and "enter" a grace period - \$/yr.

$GIMP_i$ = The importation rate - MT/yr.

$PCTCSH_i$ = Proportion of $GIMP_i$ payed for in cash (a number between zero and one)

$PWLD_i$ = The world price of commodity i (delivered at a Korean port) - \$/MT

In harmony with the current situation, all new loans are assumed to enter a grace period before repayment becomes necessary. This grace period is simulated by a distributed delay by a call to the DELDT subroutine:

9) CALL DELDT ($RGRACI_i$, $RGRACO_i$, $RINTGR_i$, DELGR, IDTGR, DT, KGR, IC)

where:

$RGRACI_i$ = Rate new loans enter a grace period (\$/yr)

$RGRACO_i$ = Rate loans leave the grace period and enter a re-payment phase. (\$/yr)

$RINTGR_i$ = An array of KGR intermediate rates.

KGR = Average length of grace period for loans - years.

At the expiration of the grace period loans enter the repayment phase. In its present form, the model assumes that no interest is paid on loans during the grace period and that this accumulated grace period interest is paid off along with principle and interest during the repayment phase. Equation (10) augments RGRACO by the accumulated interest during the grace period.

10) $RREPYI_i(t) = RGRACO_i(t)\ e^{.02\ DELGR}$

where:

$RREPYI_i$ = The total rate of new indebtedness to be repaid during the repayment phase - \$/yr. (the input to the loan repayment phase.)

DELGR = Length of the grace period - years

e = Base of natural logarithms

The variable $RREPYI_i$ therefore includes grace period interest compounded at 2% (the current applicable rate) for the length of the grace period, DELGR, and represents the rate at which indebtedness enters the repayment phase. The loan repayment phase is simulated by another call to the DELDT subroutine as shown in (11):

11) CALL DELDT ($RREPYI_i$, $RREPYO_i$, $RINTRP_i$, DELRP, INDTRP, DT, KRP, IC)

where:

$RREPYO_i$ = The rate at which loans are paid off (the rate loans "leave" the repayment phase)- \$/yr.

RINTRP = An array of KRP intermediate rates.

DELRP = The average length of the loan repayment phase - years.

KRP = A parameter that determines the probability distribution of individual loan payoff periods.

In order to compute payments to principle and interest on outstanding loans it is important to compute the total value of unpaid loans which are in the process of repayment. This variable, named, TOL_i, is computed as:

12) $$TOL_i(t) = DELRP * IDTRP * \sum_{j=1}^{KRP} RINTRP_{ij}(t)/KRP$$

where TOL_i represents the total value (\$) of outstanding loans for commodity i which are currently being paid off.

Given $TOL_i(t)$ the payments to principle and interest PPAI(t) are computed as:

13) $PPAI(t) = -(RINT*TOL(t)e^{RINT*DELRP})/(1-e^{RINT*DELRP})$

where:

PPAI = Total payment to principle and interest for outstanding loans in the repayment phase.

TOL = Total initial value of outstanding loans which are in process of being paid off.

RINT = Interest rate on unpaid balance.

DELRP = The length of the repayment period - years.

The theory underlying (13) is given in footnote 1/.

1/ Given a loan with a face (before repayment) value of BAL(0). Let BAL(t) be the unpaid balance at time t on this loan which is generating interest charges at the compounded rate of RINT per annum. Further assume that this loan is paid off at the fixed annual rate of X $/yr. Clearly the following differential equation describes this repayment process:

a) $\frac{dBAL(t)}{dt} = -(X-RINT*BAL(t))$

The solution to this equation is

b) $BAL(t)= BAL(0)e^{RINT*t} + X(1-e^{RINT*t})/RINT$

we now solve this equation for the annual payment, X^1, which will retire the loan in DELRP years:

c) $BAL(DELRP) = 0=BAL(0)e^{RINT*DELRP} + X^1(1-e^{RINT*DELRP})/RINT$

d) $X^1(t)= -(RINT*BAL(0)e^{RINT*DELRP})/(1-e^{RINT*DELRP})$

Suppose now we have many outstanding loans (the total face value before repayment equal to TOL) which have the same interest rate and terms of repayment as above. Using the results of Eqn.(d) the payments to principle and interest (PPAI) on this bundle of loans are:

e) $PPAI(t)= -(RINT*TOL(t)e^{RINT*DELRP})/(1-e^{RINT*DELRP})$

This is the equation used in the model to compute payments to principle and interest for outstanding grain loans in Eqn. 13.

We now turn our attention to government accounting for grain management costs, revenues, cash balances; etc. We do this for individual commodities and for the grain management system as a whole and also compute foreign exchange required for imports.

We begin by computing the dollar cost of imports paid for <u>in cash</u>, i.e. the foreign exchange deficit, $FOREXC_i$, to be paid in cash:

14). $FOREXC_i(t) = GIMP_i(t)*PCTCSH_i*PWLD_i(t)$

where:

$GIMP_i$ = Government imports of commodity i - ~~won~~ MT/yr.

$PCT6SH_i$ = Proportion of $GIMP_i$ paid for in cash.

$PWLD_i$ = World price of commodity i delivered to Korean ports - \$/MT.

Given $FOREX\cancel{P}C_i$ the won cost of imports paid for in cash, $CIMPW_i$ is:

15) $CIMPW_i(t) = FOREXC_i(t) * WONPD$

where WONPD is the won exchange rate per dollar.

The total won cost of imports, TWCIMP, is given by.

15a) $TWCIMP_i(t) = CIMPW_i(t)/PCTCSH_i(t)$

Under current policies this flow is transferred out of the Grain Management Special account of MAF. This usually takes place in several payments after some time lag. This fund transfer is simulated by a call to the DELDT subroutine:

15b) CALL DELDT ($TWCIMP_i$, $WTIMP_i$, $RINTWT_i$, DELIWT, IDTWT, DT, KWT, IC)

where:

WTIMP = The rate at which funds are transferred out of the Grain Management Special account to pay for imported grain - won/yr.

DELIWT = The delay in transfering funds - years.

The government costs of holding inventory, CHI, are computed as:

16) $CHI_i(t) = Cl_i * GINV_i(t)$

where:

Cl_i = The per unit cost of holding inventory - won/MT-yr.

$GINV_i$ = Government stock of commodity i - MT.

Given commodity specific costs $CIMPW_i$, $PPAI_i$, CHI_i, and revenue $GOVREV_i$ the <u>net</u> government revenue for commodity i is computed as:

17) $$REV_i(t) = GOVREV_i(t) - CIMPW_i(t) - CHI_i(t) - WTIMP_i(t)$$

The accumulated cash balance for commodity i is therefore:

18) $$CBAL_i(t+DT) = CBAL_i(t) + DT * REV_i(t)$$

The model also performs accounting for the government grain management program as a whole. The total grain management balance, TGMBAL, is computed as:[1/]

9) $$TGMBAL(t+DT) = TGMBAL(t) + DT* \left(\sum_{i=1}^{NC} REV_i(t) - COH(t) + RBOK(t) + OGREV\ (t)\right)$$

where:

RBOK = Revenues transferred to or from the grain management account from the Bank of Korea-won/yr. , or from another exogenous source.

OGREV = Other government revenue (tarrifs from wheat and feed grain imports etc.) won/yr.

REV_i = Net government revenue from commodity i (Eqn. 17).

NC = Number of commodities.

COH = Overhead costs of government grain management program - won/yr as computed by the following equation.

20) $$COH(t) = C2 * CAPINV(t) + C_4$$

1/ The variable TGMBAL corresponds to Grain Management Special Account current balance.

where:

CAPINV = Government inventory storage capacity (MT) (at this point the model does not distinguish between leased and government owned warehouse capacity).

C2 = Overhead cost of government storage - won/MT-yr.

C4 = Other overhead costs of the government grain management system (administration, etc.) - won/yr.

Government storage capacity, CAPINV, is determined by the following equations in the model. These describe a feedback control system which generate CAPINV which is adjusted to closely approximate desired capacity, CAPIND.

21) CAPINV(t+DT) = CAPINV(t) + DT*RWAREO(t)

The variable, RWAREO, is the rate at which new warehouse capacity is acquired whether through leasing or by construction and is determined by a call to the DELDT subroutine which introduces an appropriate lag into the capital acquisition process:

22) CALL DELDT(RWAREI, RWAREO, RINTWR, DELWA, IDTWAR, DT, KWAR, IC)

where:

RWAREI = The rate at which warehouse acquisition is started MT/yr. (this is the rate of new construction starts in the case of constructed warehouse capacity or the rate at which the government starts proceedings to lease private storage capacity).

DELWA = The lag in warehouse acquisition - years. (the average delay between RWAREI and RWAREO)

The variable, RWAREI, is determined as proportional to the error or difference between desired and actual government inventory capacity:

23) RWAREI(t) = C3 * (CAPIND(t)-CAPINV(t))

CAPINV(t) is computed by Eqn. (21) above. The desired inventory capacity, CAPIND in Eqn. (23), is a policy variable which can be varied from one simulation run to another in order to determent effects on government costs and the effectiveness of price control policies. If CAPIND is less than the storage required for government market operations these operations will be curtailed by the logic of Table I and government's price control objectives will not be attained. If CAPIND is set high enough to avoid constraining market operations, price policies will be more effective but government costs will increase. Varying this variable from one simulation run to another, therefore, permits users of the model to explore these trade-offs and help policy makers determine appropriate levels for government storage capacity through time.

Related to this discussion, the model computes the variable "excess inventory capacity", EXICAP, which can also assist in evaluating system performance over time:

24) $EXICAP(t) = CAPINV\ (t) - TGINV(t)$

The variable TGINV represents the total government stprage space required and is computed as:

25) $$TGINV(t) = \sum_{i=1}^{NC} GINV_i(t)$$

or the sum of storage required for all NC commodities being handled by government.

This concludes description of the main features of the preliminary government subsector model of the grain management system. In the following section we will briefly describe changes necessary in the production component of the KASS model in order to link with the remainder of the grain management system.

Modifications Necessary in the Production Component (PRODN)

This model now produces the seasonal variable $SALES_{jk}(t)$ which represents the region - specific (j= 1,2,3) sales of farm commodities (k= 1, --- 12). With relatively minor modifications this variable when summed across regions will be the aggregate, seasonally varying commercial supply input into the grain management model.

Necessary modifications to this part of the KASS model include:

1. Introduction of production losses by reducing the variable RH appropriately.

2. Fine tuning of the seasonal production and sales profiles of the model. (For rice and barley). This might include adjustments in NTSPM, and the length and order of the production delay. Also, it may be necessary to exponentially lag the variable SALES to account for lags in drying and handling grain after harvest.

3. Related to (2) is the need to make seasonal grain consumption by rural people a function of grain prices where appropriate (regression work has been started to estimate short run (seasonal) elasticities).

4. When merging the grain management model with the overall KASS sector model, the total model should be programmed to generate yearly average values for all commodities except those being dealt with on a fine time basis in the grain management sub-model. This will increase the efficiency of the total model considerably.

5. See Footnote.

Modifications Necessary in the Urban DEMAND Component of the KASS Model

Several modifications in subroutine DEMAND are necessary in order to simulate the seasonally varying demands for grain needed in the grain management system model. These include:

1. Modification of the urban population variable so that it varys smoothly over the year rather than introducing an abrupt discontinuity at yearly time intervals. This can be done by interpolating between yearly population values.

2. Programming the overall model so that it runs the demand model yearly for all commodities not being handled

5. The model must be altered to make actual sales contingent upon what sales are feasible in light of demand, ie, if there is not excess supply in the market actual producer sales may be less than the variable "$SALES_{ijk}$."

by the grain management system on a fine-time basis (everything except rice & barley). (The demand model then operates in an interative mode to determine yearly average prices for non-fine-time commodities.)

3) Introducing a seasonally varying factor into the demands for rice and barley to account for seasonal urban consumption patterns and storage by consumers. Regression analysis might be useful here as above for rural consumption.

Some Thoughts on a Model of the Private Grain Marketing Sub-Sector

While it is true that the private grain marketing sub-sector has declined in importance with the increased role of government in recent years, it is still necessary to model the storage and other behavior of the private sector in order to realistically deal with price behavior, and the effects of government actions in grain markets.

The private grain marketing subsystem is quite complex, including many different channels, levels and types of firms, etc. A detailed model which attempted to faithfully represent these many channels would be very large and perhaps needlessly complex. Thought should be given, therefore, to an aggregate model (including wholesale & retail levels together) which deals with the two major components of private demand:

1) Demand to satisfy the on-going sales to the final consumer (assuming that middlemen make a normal profit on these transactions and wish to keep the flow moving to consumers).

2. A storage demand for rice based on expected profits from storing grain. This storage demand is clearly a function of current interest rates, costs of storage, expected price increases, available storage capacity and perhaps other factors. Price expectations are based in part upon seasonal fluctuations in past years. (Forecasts based upon past seasonal behavior is readily computed using the CBOX subroutine of FORDYN).

Further study of the private marketing system for grains, including interviews with typical firms, should be carried out before finalizing the structure of this model sub-component.

A key question this part of the grain management system model must be able to address is the impact of alternative government price policies (and resulting seasonal variations) upon the storage behavior of private marketing firms.

Some Concluding Remarks on the Integration of the Sub-Components of the Grain Management Model

Taken together the four components of the total model will interact through time to determine seasonally varying market prices for rice and barley. The following price determination mechanism, found useful in other applications (the Nigerian Agricultural sector model, etc.) might also be appropriate here. This formulation assumes that prices move in response to aggregate excess demand. Market price may, therefore, be computed as:

26) $P_i(t+DT) = P_i(t) + DT * C * P_i(t) \left[PDEM_i(t) - PSUP_i(t) - GSLS_i(t)\right] / APDEM_i(t)$

where:

P_i = Producer price for grain i - won/MT (polished basis)

$PDEM_i$ = Private marketing system demand (includes demand for current transactions plus demand for storage) - MT/yr.

GSLS = Government sales (correspond to purchases if negative) - MT/yr. (This variable is computed in the government sub-model as described earlier).

$PSUP_i$ = Aggregate private supply as computed from the PRODN component by summing across regions. Mt/yr.

APDEM = Average yearly private demand (a normalizing factor) MT/yr.

C = An empirically determined constant which determines the speed of market price adjustment -- percent change in price per unit time per percent excess demand.

At any point in time dis-equilibrium may exist between total demand and total supply. At time t, then, the market clears with $TRANS_i(t)$ transactions:

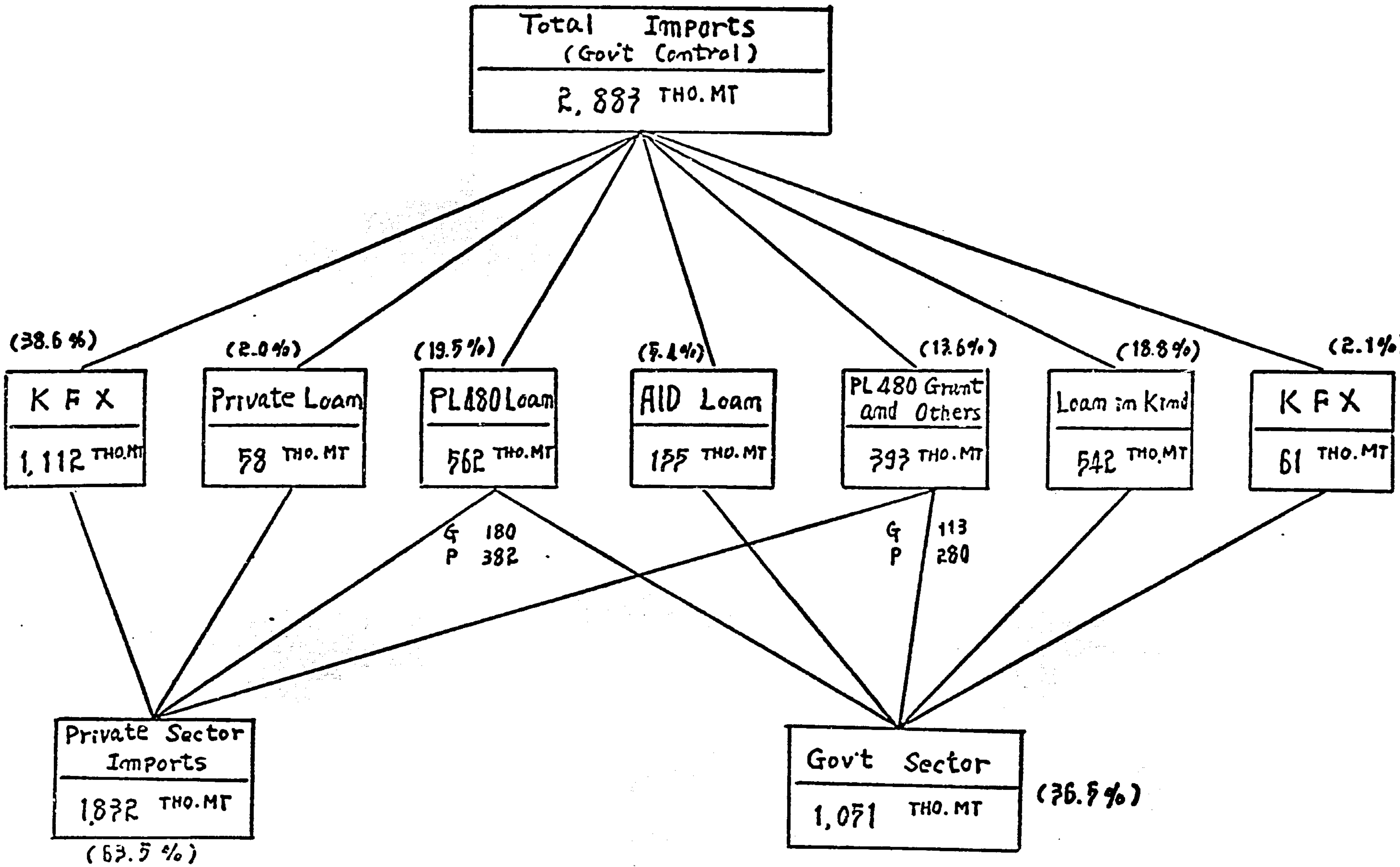
$$27)\ TRANS_i(t) = MIN\left[PDEM_i(t),\ (PSUP_i(t) + GSLS_i(t))\right]$$

a discipline (or disciplines) must be established in the model for determining how demand and supply allocate to competing entities when the market is not in equilibrium. Also, the appropriate transaction variables should influence stocks and flows and not demands and supplies.

Following merger of the four sub-components of the grain management model extensive testing is required. These tests should include comparison of model results with typical past performance of the actual system (seasonal prices, sales, quantities stored, etc.) It may be useful to compute "measures of fit between model and actual behavior for one or more years. Such tests can be used to tune and adjust model parameters for which accurate estimates are not available.

Finally, this model because of the complexity of the control problems it includes, might profit from the application of modern control theory. For example, we know that there will be interaction among price controls for various commodities, i.e. a price control on rice will also affect barley prices because of cross price elasticities of demand. Modern theory is available to assist in the design of "non-interactive" controls. In other words it is possible to design price control policies which will directly influence one commodity as desired but have relatively little impact on others.

Appendix A



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